predicts that the location is below the minimum signal strength but it is measured to be above that level. (DBS companies and their customers, of course, *benefit* from this type of "error," while local TV stations are hurt by it.)

2. Although Longley-Rice Will Work Well Once the Digital Television System is Fully Operational, There Are Major Practical Concerns About Giving Legal Effect Now to Predictions of Digital Field Strength

As discussed above, the Longley-Rice model does an excellent job of predicting whether a particular location can, or cannot, receive an over-the-air signal above the DTV minimums over the air. Because of the continuing rapid evolution of digital broadcasting, however, and in light of Congress' decision to exempt many transmitters from having their digital signal strength evaluated when they cannot be expected to broadcast in digital, there are serious concerns about whether a "digital ILLR" model makes sense in the near term.

As Meintel Sgrignoli & Wallace explain, the next several years can be divided into two distinct periods: the *long term*, after the transition from analog to digital TV broadcasting is complete, and the *short term*, before that date. MSW Engineering Statement, ¶¶81-85. In the long term, when the transition to digital is complete, there *may* be a need for a digital Longley-Rice model to predict which households are "unserved" over the air. (There may *not* be any such need, because the DBS firms may have rolled out digital local-to-local service in all markets by then.)

As discussed above, DIRECTV has already announced aggressive plans to deliver more than 1,500 local stations in high-definition by 2007, beginning with stations in 24 markets (covering 45% of U.S. television households) this year. As DIRECTV's digital local-to-local coverage increases, distant digital signals -- and the need to predict local digital signals -- will become irrelevant, given the "if local, no distant" rule adopted by SHVERA.

EchoStar has not yet announced its detailed plans for digital local-to-local service. But so long as the Commission does not create incentives for EchoStar to declare large numbers of urban and suburban subscribers to be "unserved" over the air -- as it unlawfully did with analog -- EchoStar is likely to be forced to match its cable and DBS competitors in ramping up digital local-to-local service.

In short, this pro-consumer competition to offer local digital and HD signals will make both measurement and prediction of over-the-air signal strength irrelevant in a growing number of markets – and perhaps in all 210 markets by the time the transition is complete. And given EchoStar's past abuse of analog predictive models -- including its manipulation of the analog ILLR model with three improper factors designed to treat additional customers as "unserved" -- there is special reason for caution in creating a predictive model that would, as a practical matter, be used only by the company with the worst compliance record in the television industry. *See CBS Broadcasting Inc.*, 265 F. Supp. 2d at 1248-50 (describing unlawful manipulations of analog ILLR model by EchoStar).

In any event, here are some of the practical problems with applying the Longley-Rice model in the near future:

a. <u>Congress has postponed the date on which many broadcast stations can have their digital signals evaluated</u>. In the SHVERA, Congress recognized that it would be unfair to punish a station for failing to deliver a digital signal when it cannot reasonably be expected to do so. The SHVERA therefore includes an unavoidably complex system for deciding which stations are eligible to have their digital signals tested. 39 U.S.C. § 339(a)(2)(d)(vii) ("Trigger Dates for Testing"). The schedule includes the following timetable:

April 30, 2006 trigger date for testing:

- stations in the top 100 markets that (i) have chosen a tentative digital television service channel designation that is the same as the station's current digital television service channel, and (ii) that have not been granted a testing waiver pursuant to 39 U.S.C. § 339(a)(2)(d)(vii); and
- stations in the top 100 markets that have been found by the Commission to have lost interference protection.

July 15, 2007 trigger date for testing:

- stations in the top 100 markets that (i) have chosen a tentative digital television service channel designation that is different from the station's current digital television service channel, and (ii) that have not been granted a testing waiver pursuant to 39 U.S.C. § 339(a)(2)(d)(vii); and
- stations below the top 100 markets that have not been granted a testing waiver pursuant to 39 U.S.C. § 339(a)(2)(d)(vii).

Unknown future trigger dates for testing:

- ***translator stations*** will be subject to testing "one year after the date on which the Commission completes all actions necessary for the allocation and assignment of digital television licenses to television translator stations," except to the extent that the translator station has been granted a testing waiver pursuant to 39 U.S.C. § 339(a)(2)(d)(ix);
- ***full-power stations that have obtained testing waivers*** will continue to be exempt from testing for as long as the Commission continues to approve six-month extensions of an existing waiver.

MSW Engineering Statement, ¶ 85.

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To protect stations from a draconian loss of local viewers due to circumstances beyond their control, Congress has thus created a complex and -- necessarily -- somewhat unpredictable schedule for when particular stations can have their digital signal evaluated. (Since Congress barred *site testing* of certain station's digital signals, it would be equally improper to subject them to Longley-Rice predictions about those same signals.) There is serious reason to doubt whether a system so complex and rapidly-changing will lead to accurate results.

b. <u>Those stations *exempt* from having their digital signals evaluated would need analog predictions in the interim</u>. Under the Satellite Home Viewer Act and its successors, a household is unserved if it cannot receive a signal from *any* tower transmitting a station affiliated with the relevant network (say, ABC). Thus, if a household can receive a signal from a *translator* that retransmits the signal of an ABC station, the household is not eligible to receive a distant ABC station. *See* 17 U.S.C. § 119(d)(2)(A) (definition of "network station" includes "any translator station or terrestrial satellite station that rebroadcasts all or substantially all of the programming broadcast by a network station"). Similarly, if the household can receive a signal from a nearby ABC station in a different market, it is ineligible to receive a distant ABC station, whether or not the household can receive the station in its own DMA over the air. *See CBS Broadcasting Inc.*, 265 F. Supp. 2d at 1249 (describing improper exclusion by EchoStar of signals from stations in other DMAs).

As described above, Congress has decreed that certain towers may not have their digital signal evaluated until some time in the future: stations in markets 101-210 may not be evaluated before July 2007 at the earliest; translator stations may not be evaluated until a much later date;

and individual stations that receive temporary testing waivers from the Commission will have varying dates on which their digital signals are subject to evaluation.

This schedule creates a practical conundrum: if a station cannot be tested -- and therefore could not have its digital signal evaluated in the Longley-Rice model -- how is the station to be treated in the testing or prediction process? Meintel Sgringnoli & Wallace give the example of household near the Shenandoah Mountains in Virginia that is predicted to (and does) receive an analog signal of a Washington, D.C. network affiliate from a translator station. Congress has directed that the digital signal of this translator station cannot be evaluated until some future date – which is only fair, since the translator does not even have a digital channel assignment as of now. How should this translator tower be treated for purposes of tests or predictions?

What Congress must have had in mind is that, if a station is not yet eligible to have its digital coverage evaluated, one must look to the station's *analog* service. Thus, when a *test* is performed, the engineer must look both for the digital signal of any affiliate of the relevant network (say, ABC) and *also* for the analog signal of any tower in the area that is not yet subject to digital testing. This is the logical way to give stations "credit" for their coverage when they have been excused -- for the time being -- from digital testing. MSW Engineering Statement, ¶ 89.

The need to conduct both digital and analog tests, and to determine which stations are and are not subject to digital testing, will add further complexity to the task of conducting tests starting in April 2006 pursuant to SHVERA. Adding these additional twists to a *nationwide predictive model*, however, may take matters over the edge.

c. <u>**Station channel assignments are still in flux**</u>. The "repacking" process, designed to place all digital TV stations in Channels 2-51, is ongoing. And under the timetable announced last week in MM Docket No. 03-15, not until August 2006 will the Commission issue a Notice of Proposed Rulemaking proposing a new DTV Table of Allotments, which will then be subject to comment by the public and potentially to significant revision by the Commission thereafter. The continuing movement by stations to different channels will add a further challenge to both the testing process and to application of the Longley-Rice model.

D. Even If Congress Does Not Alter the Act to Make Subscribers Eligible Based on Predictions about Digital Service, the Law Already Authorizes Signups for Distant Digital Signals Based on the *Analog* ILLR Model

The "three-dimensional chess" quality of a digital Longley-Rice model applied in the current transitional environment no doubt explains why Congress elected to rely on field measurements, rather than a predictive model, to decide whether individual subscribers can receive distant digital signals based on the claimed absence of an over-the-air digital signal. That is, when a *test* is conducted, knowledgeable people on the ground (such as station personnel) can at least try to ensure that the tester knows the relevant facts. But when a satellite carrier runs a computerized predictive model at its headquarters, there is little a station can do to protect itself.

At the same time, in an ideal world, it is desirable to be able to rely on a predictive model as well as measurements. Fortunately, the Act allows DBS companies to sign up subscribers for distant digital signals -- based on the well-defined *analog* ILLR model, with which both broadcasters and DBS companies have years of experience. That is, under pre-existing law, as extended by SHVERA, the DBS firms can retransmit a *digital* signal of (for example) an ABC station to a household that is predicted to be unable to receive an analog signal of an ABC station over the air. While imperfect, there is an undeniable logic to this interim rule, since the goal of the digital transition is, after all, to replicate TV stations' analog coverage areas. In any event, both DBS companies and their subscribers will continue to enjoy the convenience of relying on a predictive computer model to determine eligibility to receive distant digital signals.

E. "Fifth Generation" Receivers, Which The DBS Firms Can Build Into Their Set-Top Boxes, Do Much Better <u>In Handling Difficult Reception Environments</u>

Finally, the Commission asks (¶ 7) about the differences in reception ability between different types of digital TV sets and digital receivers. We provide the Commission in this section, and in the accompanying engineering report, with extensive data responsive to that question.

Even though the tests were done with early-generation receivers, real-world field tests show that the availability of a signal above the DTV minimum signal strength is a very good proxy for ability to receive a high-quality DTV picture. *See* above. Conveniently, that already high success rate will shoot up still further in the near future: *fifth generation* DTV receivers achieve much better performance in the difficult reception environments (such as multipath) that contributed to the small number of reception failures in past tests. Since satellite subscribers regularly replace their set-top boxes for a wide variety of reasons, and since DirecTV and EchoStar firms are currently in the process of switching their customers to new set-top boxes to use MPEG-4 compression, it will be a simple matter for most DBS customers to be able to take advantage of this advanced technology.

We anticipate that some commenters may urge that the Commission must assume use of outdated receivers because some subscribers have such receivers. But as previously discussed, *even with early-generation receivers*, DTV signal intensity is a very good proxy for actual DTV reception -- making the "which generation of receivers" issue of little relevance. Moreover, while the DBS companies have tens of millions of subscribers, the number of DBS subscribers who have *high-definition* receivers is only a tiny fraction of the DBS companies' total subscriber base. And even among those households, only a few will be unable (even with an older receiver) to translate an above-minimum field strength into a digital picture.

* * * * * * *

In response to the Commission's questions, NAB's outside engineers have provided a detailed description of advances in digital receiver technology. *See* MSW Engineering Statement, ¶¶ 93-103. In brief, there have been several generations of 8-VSB receivers during the digital era, with the most important advances being realized in the fifth generation boxes. As a recent paper published in an IEEE journal discusses, the new generation of receivers conquers difficult reception problems -- such as multipath -- that confounded earlier generations of receivers. *See* T. Laud, M. Aitken, W, Bretl, & K. Kwak, *Performance of 5th Generation 8-VSB Receivers*, 50 IEEE Transactions on Consumer Electronics, No. 4 (Nov. 2004) (Attachment 3 hereto). This remarkable improvement has been seen both in lab tests (against so-called "ensembles" of heavily-multipathed signals) and in field tests, in which engineers have returned to extremely difficult environments (such as Rosslyn, Virginia) that were part of the small minority of locations that, using previous generations of receivers, had adequate signal strength but nevertheless had reception problems. The improvements have been so dramatic that previous critics of the 8-VSB system, such as Sinclair Broadcasting, now strongly endorse that system based on the results of testing of fifth-generation receivers. MSW Engineering Statement, ¶ 114 (quoting Sinclair representatives).

F. The Addition of an Extra Clutter Factor for DTV Would Make the Longley-Rice Model Less Accurate in Predicting Whether Households Can Receive the Minimum DTV Field Strength

The Commission also asks (NOI, ¶ 7) whether it should add an extra "clutter" factor to the standard digital Longley-Rice model. As Meintel Sgrignoli & Wallace explain, the Longley-Rice model is partially based on actual field measurements, and thus *already* takes clutter into account to a significant degree, because clutter affects real-world field measurements. MSW Engineering Statement, ¶ 77. In any event, as the Commission found in 2000, whether a special "clutter factor" will improve the accuracy of the Longley-Rice model is a question that can and should be addressed by *empirical* data. *In Re Establishment of an Improved Model for Predicting the Broadcast Television Field Strength Received at Individual Locations*, First Report and Order, FCC 00-185 (May 26, 2000).

Since no predictive model can achieve 100% accuracy, *see* NOI ¶ 15 n.14, the criteria for evaluating whether a predictive model is functioning well are (1) whether it achieves a high level of accurate predictions and (2) whether its errors are roughly balanced between overpredictions and underpredictions. In evaluating the *analog* ILLR model in 2000, the Commission found that adding a clutter factor for analog UHF channels was desirable, because the model was otherwise somewhat tilted towards overpredictions. On the other hand, the Commission found that adding a clutter favor for analog VHF channels would make it *less* accurate by tilting it towards underpredictions. *In Re Establishment of an Improved Model for Predicting the Broadcast Television Field Strength Received at Individual Locations*, First Report and Order, FCC 00-185 (May 26, 2000).

Meintel Sgrignoli & Wallace have performed a similar analysis of the Longley-Rice model for *digital* signals, looking at the small percentage of predictive errors to determine how they split between over- and underpredictions. MSW Engineering Report, ¶¶ 78-79. The analysis shows that the model is already in balance *without* the addition of any additional clutter factor. A special clutter factor would put a thumb on one side of the scale and therefore reduce, not enhance, the accuracy of the Longley-Rice model for digital signals.

Conclusion

For these reasons, the Commission should make recommendations concerning testing and prediction of over-the-air digital signals in accordance with the suggestions discussed above.

Respectfully submitted,

/s/

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June 17, 2005

ATTACHMENT 1

Before the
Federal Communications Commission
Washington, D.C. 20554

In Re Technical Standards for Determining	)	
Eligibility for Satellite-Delivered Network	)	**ET Docket No. 05-182**
Signals Pursuant to the Satellite Home	)	
Viewer Extension and Reauthorization Act	)	

Engineering Statement of Meintel, Sgrignoli,
& Wallace Concerning Measurement
and Prediction of Digital Television Reception

1. At the request of the National Association of Broadcasters, the undersigned have prepared this engineering statement for consideration by the Commission in connection with its inquiry into available methods for measuring and predicting the ability of households to receive over-the-air digital television signals. The credentials and experience of the undersigned are set forth in the attached as **Exhibit A.** As detailed there, we have, among other things, conducted thousands of digital signal intensity tests in a variety of locations around the United States; helped to design and test state-of-the-art digital receivers; and developed industry-standard computer-based analysis applications and specialized software concerning RF propagation. We attempt in this Engineering Statement to provide the Commission with the benefit of this experience. We begin with a short discussion of pertinent background facts, before addressing the specific issues raised by the Commission.

INTRODUCTION AND BACKGROUND

Analog Television and the Beginnings of the Digital Era

2. Black and white analog television, commonly referred to by reference to its origins with the National Television Systems Committee (NTSC), was adopted as the standard in the United States in 1941. The analog color TV system was adopted in December 1953.

3. In 1987, 58 broadcast organizations petitioned the Commission to develop high definition television (HDTV) standards in the United States to remain competitive with new, emerging technologies. The FCC immediately created a multi-industry advisory committee to study this topic, calling the group the Advisory Committee on Advanced Television Services (ACATS).

4. After six years of competition and at the suggestion of the ACATS group, a consortium of companies banded together in May 1993, calling itself the Grand Alliance (GA). Over the subsequent two and one-half years, a digital television system was developed and thoroughly examined, with prototype hardware evaluated in both the laboratory and the field. In November 1995, the ACATS group recommended this system to the FCC as the next television system for the United States. From this work, the Advanced Television Systems Committee (ATSC) developed and documented a standard **(Ref 1)**.

Commission Implementation of the Transition to Digital Television, Based on the Assumption of Properly-Oriented Rooftop Receive Antennas

5. In December 1996, the FCC adopted the ATSC system as the new digital television standard for the United States **(Ref 2)**, thus officially beginning the transition from the old analog NTSC system to the new digital ATSC television system. In April 1997, the FCC issued its rules for digital operation **(Ref 3)**. The Commission also made public its first set of channel allocations, lending each U.S. broadcaster a second 6 MHz channel for digital television transmission **(Ref 4)** for the purpose of replicating the station's analog NTSC service area. The next year, in February 1998, the Commission issued a revised set of allocations with additional and revised rules **(Ref 5)**.

6. The Commission's procedures for allocating digital TV channels were based on a set of "planning factors" concerning DTV transmission and reception. (We discuss these

planning factors in greater detail below.) Of particular importance to the current inquiry, the FCC's planning factors assume a *typical* receive site with predetermined antenna gain and directivity, antenna height nine meters above ground level (AGL), antenna dipole factor, downlead loss, receiver noise figure, DTV signal-to-white noise (SNR) threshold of errors (≈ 15 dB), and desired-to-undesired (D/U) interference ratios (between DTV and NTSC signals as well as between DTV and other DTV signals).

7. As discussed in greater detail below, these planning factors for the DTV receive antenna setup are reasonable based on readily available, and moderately priced, equipment available to consumers in the marketplace. For around $40, for example, a household can purchase an excellent rooftop antenna (the Channel Master 4228) with gain figures for UHF and high-VHF channels (on which almost all network affiliates will operate) above those specified by the Commission in its DTV planning factors. And for a similarly modest expenditure, consumers can acquire a low-noise amplifier (LNA) or "preamplifier," which will enable consumers to *exceed* the DTV reception performance assumed in the digital planning factors.

8. The FCC's planning factors, first described in the April 1997 Sixth Report and Order (**Ref 4**), were further clarified in Bulletin 69 (**Ref 6**) from the Commission's Office of Engineering and Technology (OET). OET Bulletin 69 is a set of guidelines on "Longley-Rice Methodology for Evaluating TV Coverage and Interference" to aid broadcasters.

9. In determining the service area of *analog* TV channels, the Commission has always assumed use at the receive site of a properly-oriented *rooftop* antenna with significant gain. (We understand that the Satellite Home Viewer Act of 1988 and its successors have done so as well.) When the Commission sought to replicate stations' current analog service areas in its assignments of *digital* channels, it likewise assumed use of such a rooftop antenna. Had the

Commission instead assumed use of an indoor antenna (or of a low-quality or improperly-oriented rooftop antenna), the digital channel allocation process, and the Commission's determination of the amounts of power authorized to be used by stations, would have been entirely different. For a station to be expected to deliver a digital signal viewable via an *indoor* antenna at a distance of 50 miles from the tower, for example, it would need to transmit at an enormously higher power level than the Commission has authorized. In turn, the Commission's calculations concerning avoidance of interference would have been radically different if it had assumed that DTV stations would transmit at the extraordinary power levels needed to replicate analog coverage areas via use of an indoor (or poor-quality outdoor) antenna for digital reception.

10. The digital terrestrial standard is described in the FCC rules and regulations **(Ref 7)**. Full service U.S. broadcasters, as part of the DTV build-out schedule, are now implementing terrestrial DTV, which consists of standard definition and high definition video signals, 5.1 channel (5 full bandwidth, 1 low bandwidth subwoofer) compact-disc quality audio, and the capability of a plethora of ancillary data services. Digital low-power TV (LPTV) and translators were first addressed in the Commission's rules as of September 2004. However, television translators and LPTV broadcasters have not yet received licenses for additional DTV channels. (Even after receiving channel assignments, translators and LPTV stations will need time to build out their digital facilities.) As discussed below, these and other timing issues create a serious challenge in implementing a digital predictive model for individual households in the near future.

The Repacking Process

11. During the transition from analog to digital television, broadcasters were given an extra 6 MHz channel for transmitting their digital ATSC DTV signal. However, it was always known that stations would be required to return one of their two channels in the future. As the transition enters its final phase, the broadcasters must not only give up the extra channel, but must also squeeze their digital channels into the range that the Commission has designated as the "core" spectrum, namely Channels 2-51.

12. Spectrum repacking is the process through which TV stations determine whether to keep their current DTV channel (if it resides in the core), move back to their original analog channel (if it resides in the core), or find a new channel in the core. Spectrum re-packing began in earnest in January 2005, and is currently moving forward as broadcasters are selecting their final DTV post-transition channels.

Very Few Network Affiliates Will Broadcast Digital Signals on Low-VHF Channels

13. As of today, there are roughly 43 broadcast stations with a low-VHF digital channel. It appears that very few broadcasters want to keep these low-VHF channels, and it is expected that fewer than 30 of the approximately 1,700 TV stations will broadcast in digital on low-VHF channels. For purposes of the present inquiry, of course, the stations of interest are Big-4 (ABC, CBS, Fox, NBC) network affiliates. Currently, only about 27 network affiliates have digital channels in the low-VHF range, and that figure may decrease, or at most increase slightly, as the repacking process proceeds.

The ATSC Transmission System

14. The ATSC data transmission system is digital Vestigial Side Band (VSB), and includes two modes: a trellis-coded 8-VSB mode for terrestrial use and a high data-rate 16-VSB mode for cable use. The ATSC system is described in **References 8, 9, and 10**.

15. The ATSC's 8-VSB system transmits 19.4 Mbps over a 6 MHz RF channel utilizing vestigial modulation (lower RF sideband is missing). All FCC-licensed power measurements use the *average* power of the VSB signal, and are made across the *entire* 6 MHz channel bandwidth. A small CW pilot is added to the randomized, noise-like signal that has very similar characteristics to white Gaussian noise.

16. An MPEG-transport stream of 188-byte data packets is inserted into the VSB exciter, with one MPEG packet placed within one VSB transmission data segment. Forward error correction is employed in the form of a cascaded trellis-coded modulation scheme (2/3-rate, 4-state, Ungerboeck code) with a Reed-Solomon coding scheme (187, 207, t=10) that can correct up to 10 byte errors per data segment (packet).

17-22. [Intentionally omitted.]

The FCC Planning Factors For Digital Service

23. The planning factors recommended by ACATS were first described in the FCC's Sixth Report and Order (**Ref 4 Appendix A**). These factors are for use with the Longley-Rice predictive software for determining NTSC and DTV *outdoor* field strengths regarding service coverage and interference evaluation. The Sixth Report and Order describes the methodology for predicting field strengths using terrain models. OET Bulletin No. 69 (**Ref 6**) further clarified the implementation and use of the Longley-Rice software methodology for evaluation of *outdoor* TV coverage and service.

24. As indicated above, the FCC's goals are to *replicate* the analog NTSC Grade B coverage area with the new digital ATSC system. The Grade B coverage area (Section 73.688 of the FCC rules) of a TV station is determined using the FCC(50, 50) statistical field strength curves (Section 73.699 of the FCC rules). The distance to the NTSC Grade B contour in a given direction from the transmitter is determined by the field strength value shown in **Table 1** for the geometric mean frequency within each of the three television bands. The DTV field strength values in **Table 1** are then used with the FCC(50, 90) curves to determine the maximum effective radiated power (ERP) in a given direction that matches the NTSC Grade B distance (but keeping the DTV ERP values between 50 kW and 1 MWatt for UHF, between 3.2 kW and 316 kW for high-VHF, and between 1.0 kW and 100 kW for low-VHF). This then defines the DTV area subject to calculation. The Longley-Rice radio propagation model is then used to make NTSC and DTV predictions of the RF field strength at specific geographic points based on the elevation profile of terrain between the transmitter and any reception point. The predicted field strength values for both NTSC and DTV within their respective contours determine whether each system is expected to deliver service at a particular receive site.

25. The Longley-Rice computer software that supplies these predictions is published in an appendix of an NTIA Report (**Ref 11**). Subsequently, G.A. Hufford described modifications to the software code in a memo dated January 30, 1985. This modified code is referred to as Version 1.2.2 of the Longley-Rice model, and it is the version used by the FCC for spectrum allocation evaluation.

26. OET Bulletin No. 69 was eventually updated with certain new parameters, and published in a revised version in February 2004 (**Ref 6**). Certain adjacent channel desired-to-

undesired (D/U) interference ratios were corrected. These new values were also reflected in the FCC rules, and are the ones that will be described in this report.

Receive Site Planning Factor Values

27. To evaluate TV service coverage, the Longley-Rice predictive software determines whether a particular location is expected to receive a signal of a certain specified minimum (or "threshold") field strength. The field strength minimums are, of course, different for analog and digital, and also depend on which channel band is being considered. As the Commission observes in the NOI, "[f]or DTV stations, the counterparts to the Grade B signal intensity standards for analog television stations are the values set forth in Section 73.622(e) of the Commission's rules describing the DTV noise-limited service contour." NOI, ¶ 2. (We understand that the Act incorporates by reference the specific dBu levels, by channel band, that are set forth in the Commission's rules.) The minimum values, as set forth in the rules, are as follows:

Channel Numbers	Channel Label	Defining NTSC Field Strength Using F(50, 50) Curves (dBμV/m)	Defining ATSC Field Strength Using F(50, 90) Curves (dBμV/m)
2-6	Low VHF	47	28
7-13	High VHF	56	36
14-69	UHF	64	41

Table 1 NTSC and DTV defining field strengths for use in FCC spectrum allocation planning

28. Note that the NTSC defining field strengths are determined using the traditional F(50, 50) statistical field strength prediction curves, while DTV defining field strengths are determined using F(50, 90) curves: that is, the curves predict a given field strength (or higher) for a given transmitter effective radiated power (ERP), and a given transmitter antenna height

above average terrain (HAAT) that occurs at a given distance from the transmitter at 50% of locations and 90% of the time. (The analog field strength figures, however, include an extra 6, 5, and 4 dB for the three channel groups which raise the time fading factor from median (50%) to 90 percent; in effect, then, the analog system is intended to deliver an acceptable picture 90% of the time at 50% of locations.)

29. In addition, while the two VHF bands have fixed minimum required field strength values for their entire respective frequency bands based on their geometric mean frequency, the FCC chose to modify UHF band values with a correction factor. This correction represents the dipole factor, which takes into account the fact that for a given RF field strength, the voltage output from a ½-wave dipole antenna (terminated in a matched impedance) decreases with increasing frequency.

30. The NTSC field strengths in **Table 1** are the same as those used over the years. However, the DTV field strength values in **Table 1** are determined from the DTV planning factors identified in **Table 2**, and statistically characterize the equipment -- including outdoor antenna systems -- used for home reception. That is, they represent a "typical" DTV receive site system in the modern era.

Planning Factor	Symbol	Low VHF	High VHF	UHF
Geometric Mean Frequency (MHz)	F	69	194	615
Geometric Mean Wavelength (m)	λ_m	4.3	1.5	0.5
Geometric Means Wavelength (feet)	λ_{ft}	14.3	5.1	1.6
Dipole Factor nominal (dBm-dBμ)	K_d	-111.8	-120.8	-130.8
Dipole Factor adjustment	Ka	None	None	See text
Thermal Noise (dBm/6 MHz)	N_t	-106.2	-106.2	-106.2
Antenna Gain (dBd)	G	4	6	10
Antenna Front/Back Ratio (dB)	FB	10	12	14
Downlead Line Loss, 50' cable (dB)	L	1	2	4
System Noise Figure (dB)	N_s	10	10	7
Required Carrier Noise (dB)	C/N	15	15	15
Calculated Minimum Rx Power (dBm/6 MHz)	P_{min}	-81	-81	-84

Table 2 FCC's planning factors for a typical DTV receive site.

31. The minimum required DTV field strengths can be obtained from the planning factors in **Table 2** by viewing the block diagram in **Figure 1.** The equation for the minimum required field strength E at the input to the antenna can be created by starting at the DTV receiver input and working back to the antenna. The equivalent noise floor at this point is the kTB noise (i.e., the theoretical amount of noise in a matched resistor) plus the noise figure (NF1) of the receiver (*i.e.,* the excess noise that the imperfect receiver adds to the theoretical kTB noise). The minimum required S/N ratio for the 8-VSB system is added to the noise floor, providing the minimum required signal level at the input of a DTV receiver for error-free operation. The coaxial cable downlead loss (L) is then added, providing the minimum required signal power at the output of the antenna. The dipole factor (Kd) is then taken into account, which consists of two components: the conversion between voltage to power as well as the dipole antenna conversion between field strength and voltage. The resulting field strength is the minimum required level at the input of a ½-wavelength dipole antenna for error-free DTV operation. However, the FCC's planning factors account for a typical receive site that uses a directional outdoor antenna with directivity and gain (Ga) that is then subtracted, indicating that

less field strength is needed when an antenna with gain is employed. The following equation represents the DTV field strength calculation, along with the UHF receive site parameter values:

$$E\,(\mathrm{dB\mu V/m}) = (Nt + NF1) + SNR + L + Kd - Ga$$

$$E\,(\mathrm{dB\mu V/m}) = (-106.2\ \mathrm{dBm/6\ MHz} + 7\ \mathrm{dB}) + 15.2 + 4 + 130.8 - 10 = 40.8\ \mathrm{dB\mu V/m}$$

32. The above value of 40.8 dBμV/m, which the FCC rounds to 41 dBμV/m, is for Channel 38 (*i.e.*, 615 MHz) only. In OET Bulletin 69, the minimum field strength at other UHF channels is determined by applying the dipole factor. (As mentioned, for purposes of SHVERA, Congress has "locked in" 28, 36, and 41 dBu as the relevant field strengths for the three channel bands.)

33-35. [Intentionally omitted.]

The Commission's Planning Factors
<u>For Digital Reception Equipment</u>

36. In its Notice of Inquiry, the Commission asks for comments on a number of issues relating to consumer equipment setups. We address those issues here.

37. <u>Rooftop versus indoor antennas</u>. The Commission asks whether the digital reception standard should be premised on a *rooftop* antenna or instead on an *indoor* antenna. NOI, ¶ 7. For several reasons, the logical choice is to assume a rooftop antenna.

38. First, the reception characteristics of indoor antennas are much worse than those of outdoor, rooftop antennas. As a recent research paper confirms **(Ref 12)**, indoor antennas have much less gain -- and in some cases actual losses as compared to a dipole -- while good outdoor antennas offer substantial gain, in line with the Commission's planning factors. Also, because indoor antennas are placed at a lower height (sometimes below ground) and behind walls, their lower inherent gain (or loss) characteristics are exacerbated. *See* NOI, ¶ 20 ("indoor-mounted antennas will generally receive weaker signals than outdoor-mounted antennas"). In

addition, indoor antennas generally have little or no directivity and therefore they are more susceptible to reception problems from both multipath and interference. They are also affected by the movements of people near the antennas, which can abruptly change the antenna's reception pattern.

39. Because of these many ways in which rooftop antennas are superior to indoor antennas, households have long used rooftop antennas to achieve over-the-air reception. In fact, many rural viewers have placed large (high gain) over-the-air antennas *higher* than rooftop level, on small towers near the household. These tower setups not only provide more signal level (because of higher gain and higher elevation) but also reduce multipath effects with greater antenna directionality.

40. A second reason rooftop antennas are the logical choice is this: the households at issue are those of satellite subscribers -- and satellite reception antennas (usually called "satellite dishes") can only be used outdoors, typically on a rooftop. An "indoor" satellite antenna would simply not function. Since satellite antennas must be located outdoors, and usually on the roof, there is no reason over-the-air antennas cannot be similarly located.

41. Third, the entire process of allocating digital channels to TV stations, of determining their coverage area, of replicating analog coverage areas, and of assessing the power levels at which the stations should operate, are all critically based on the assumption of a rooftop over-the-air reception antenna. As the Commission correctly observes in its NOI, the minimum DTV field strengths for the noise-limited contour "presume that households will exert similar efforts to receive DTV broadcast stations as they have always been expected to exert to receive analog NTSC TV signals." NOI, ¶ 6. Broadcasters are building an multibillion-dollar digital

broadcast system premised on rooftop antennas, and it would be a fundamental change in engineering principles -- with very large economic consequences -- to reverse course now.

42. **<u>Proper vs. improper antenna orientation</u>**. The Commission also asks whether it would be appropriate to assume that the over-the-air antenna is properly oriented to achieve the best reception from the station in question. NOI, ¶ 7. For reasons similar to those just discussed, the Commission should assume proper orientation.

43. First, as with the rooftop-vs.-indoor issue, a DBS household gets no satellite reception unless its dish is *precisely oriented* towards the carrier's geosynchronous satellite. Holding the household's over-the-air antenna to the same expectation appears reasonable. Second, as discussed above, the Commission's entire effort in developing its digital television assignments has been grounded in the assumption of properly-oriented rooftop antennas for reception of digital television signals.

44. Of course, in many markets TV towers are (nearly) co-located, making it possible to orient a *fixed* rooftop antenna accurately towards all of the network affiliate towers in a particular market. This is particularly true for viewers that are some distance from the transmitter locations because the farther the viewer is from the transmitter, the *difference* in bearing angles for the various stations become smaller. In general, many markets have essentially co-located facilities which makes the orientation of the receive antenna a simple matter. Currently, about 83% of the television markets with four network affiliates (112 of 135 markets) have essentially co-located transmitter sites. In these markets, a single antenna oriented in the general direction of the transmitter sites should be sufficient for good digital television reception. To the extent that towers are located in different directions in other markets, local electronics installers may offer a special, fixed antenna that is designed to receive signals from